

INFORMED

For Medical Professionals in Neuro, ENT and Spine



Focus: Connectivity





Dr. Hans-Joachim Miesner

Dear Readers,

Network connectivity seems to be a common trend affecting nearly every aspect of our daily lives. In fact, without the creation of the Internet some 40 years ago, we might not be talking about the flattening of the world right now. Due to the increased connectivity and collaboration, more people than ever can work together to develop products and provide services.

The resulting synergies have produced amazing innovations and the technological advancements of the last few years have been dramatically shaping our world and bringing it closer to us.

Consequently, this trend has been making its way into the OR. With the electronic integration of almost all clinical data and the capability to capture, archive and share clinical information and images, the medical field is becoming more and more networked. Having access to skilled physicians not available on site and the ability to share knowledge with others beyond the facility's boundaries are benefits for everyone.

The enormous technological and scientific progress is leading to innovations that open up new opportunities in all medical specialties.

Surgical equipment is and will be more and more sophisticated in the future. Nothing will operate in a vacuum anymore.

This fourth edition of INFORMED will shed some light on what the future may hold for the integrated OR as well as trendsetting ideas for visualization and connecting excellence. We will look at both connectivity's achievements and some ideas for it in the future.

We hope you will enjoy these articles and continue to find INFORMED interesting and useful. Any ideas or suggested topics for the upcoming editions will be gratefully received. For this reason, we invite you to send us your comments using the postcard at the back of this issue.

Happy reading!

Yours,

Hans-Joachim Miesner

Director Neuro/ENT & Spine



<i>Get Ready to Get Wired</i>	6 - 9
Making the right connections	
<i>See It All Come Together</i>	10 - 13
An interview with Robert F. Spetzler, M.D.	
<i>The Future of the Surgical Microscope in the Integrated OR</i>	14 - 17
Jürgen Meixensberger, M.D., Ph.D.	
<i>The Integrated OR: New Horizons in Improving the Surgical Workflow</i>	18 - 21
An interview with Paolo Cappabianca, M.D.	
<i>Defying Gravity: Surgery in Space</i>	22 - 25
Thomas Weber, Dr. rer. medic. Dipl.-Ing.	
<i>Through the Lens of a Biomed Photographer: How to Take Good Pictures?</i>	26 - 30
Gary L. Armstrong	
<i>Expanding the Horizon of Clinical Education – Practical Anatomy & Surgical Education Saint Louis University School of Medicine</i>	31 - 35
Karen Hutsel, M.S.N., R.N.	
<i>Visualizing a Virtual Cockpit</i>	36 - 38
OPMI® Application Tip #4	
<i>Microscope-integrated, Intraoperative, Near- infrared ICG Videoangiography in the Case of Cerebral Arteriovenous Malformations</i>	39 - 42
Yasushi Takagi, M.D., Ph.D.; Nobuo Hashimoto, M.D., Ph.D.	
<i>Facts and Figures</i>	43





Get Ready to Get Wired

Making the right connections

Which of these terms were in existence 10 years ago – Facebook, Gmail, Blackberry and iPod? There was only one – and it was just known as a fruit. Let's face it, technology is bringing the world ever closer and changing the way we experience our everyday lives.

This progress has even entered our hospitals. The technological advances achieved by getting connected within the OR and its environment have revolutionized surgery and opened new horizons for sharing information and knowledge.

The word “connectivity” seems to engulf the world around us – providing a visual where everything is somehow inter-connected. But connectivity is more than just a techno-social phenomenon. Networks seem to affect every aspect of our daily lives. These networks form a foundation of today’s world where you can communicate instantly and easily with anyone across the globe. The Internet, for example, has already changed the way people do business, exchange ideas, collaborate and socialize with one another. Today, almost one quarter of the world’s population is online and uses the Internet on a daily basis. Tim Berners-Lee, the inventor of the World Wide Web, has just weighed in on this connectivity question in a podcast interview for IBM: “The idea of the Web as interaction between people is really what the Web is. That was what it was designed to be as a collaboration space where people can interact.”

The digital age of connectivity has also begun to enter many hospitals. Today, the medical field is becoming more and more networked with almost all clinical images, medical records and supply management information available from virtually anywhere within the clinical IT network. These networks often come complete with centralized control panels within the OR and real-time teleconferencing establishing an opportunity to provide remote learning via telesurgery broadcasting.

Things that go boom

Over the course of the last decade, an information and technology revolution has taken place inside the operating room. OR management systems, for example, simplify the workflow during surgery by providing solutions ranging from patient administration via OR planning to video documentation and live transmission to monitors both inside and outside the OR. An intra-operative MRI can provide the surgeon with real-time feedback. Ultrasonic systems allow the tracking of tissue movement during surgery. The integration of navigation systems provides high-level accuracy in image-guided surgery by linking intra-operative images with the spatial position of the surgical instru-

ments relative to patient’s anatomy. Finally, surgical microscopes also play an integral part of the operating room by providing an interfacing platform with ideal conditions for merging the diverse information tracked in the OR. With the integration of a micro display, additional information from the navigation system, for example, can already be projected into the eyepieces of the surgical microscope and superimposed on the surgical scene. Moreover, the surgeon is able to have diagnostic images and video data from MRI, CT, ultrasound, and even an endoscope directly injected into the microscope’s eyepieces.

The surgical microscope also provides an ideal platform to directly integrate new dimensions in visualization like the completely integrated microscope-based fluorescence options of OPMI Pentero used for fluorescence based tumor resection.

Connecting all these hardware and software components with each other would make it possible to manage the complete OR technology from one single boom system within the sterile area – or even from the surgical microscope itself.

Getting connected – anytime, anywhere

The current trend is not only to electronically integrate all clinical data, but also to capture, archive, access, and share clinical images, medical records, lab results or supply management information. Paperwork and films are starting to go the way of the dinosaur. Intraoperatively generated pictures can be saved and centrally archived within the clinical IT network. By combining them with patient data as well as pre- and post-operative diagnostic images, a complete set of diagnostic and intraoperative images for every patient can be created. This direct linking of images with all kinds of demographic and patient-specific data greatly simplifies data management and allows efficient allocation within the network (e.g. for review in another hospital or doctor’s office). Having access to all image data at any time and at any appropriate workstation provides an excellent basis for discussing cases with colleagues or sharing information for educational purposes.

Patient information, images, and videos can also be accessible in the OR on a real-time basis. The OR team does not have to leave the room or call out for additional information during the procedure. Physicians are able to dedicate more of their time and skills to patients and education rather than on paperwork and logistics. The exchange of in-depth information in real-time can also help facilitate a complicated surgical decision process opening new possibilities for telemedicine.

Tele-capabilities

To communicate with the skilled physicians not present in an OR and to share knowledge in real-time are exciting capabilities for live video feed communication. Surgeons are able to teleconference and communicate audio-visually in real time with external sites and transmit operations live via the Internet. Those video conferencing systems allow students and other observers to interact live with surgeons in the OR while seated in a hospital's conference room thousands of miles away. Teleconferencing technology will become the base-

line for more advanced applications like telementoring, the ability to sketch surgical notes directly onto the surgeon's monitor from miles away to supervise or comment on the procedure. By connecting experts during the procedure, knowledge synergies can be fostered.

The shape of things to come

Medical progress is forging ahead and developments in the field are advancing at a tremendous rate. The enormous technological and scientific progress is leading to innovations that will open new opportunities in all medical specialties. New imaging technologies, for example, can improve the localization accuracy of navigation systems allowing for enhanced performance of highly precise navigation procedures and robot-assisted surgery. Image-guided robotics are already being used with the CyberKnife® technology to deliver surgically precise radiation to destroy lesions without the need of invasive surgery. CyberKnife® uses image guidance to track bony landmarks or small markers that have been implanted in the tumor.



Fig.2: The surgical microscope provides an ideal networking solution for various types of information.



Fig.3: Live transmission from the OR allows to interact live with surgeons in the OR.

We are already expecting the development of GPS-like systems for tracking the movement of cancerous tissue during radiation therapy using electromagnetic positioning transponders which are about the size of a grain of rice. Telemedicine might even become the standard of care for small rural hospitals where specialists are just not available. Experiments with telemedicine on the battlefield are already in the works. Another aspiration is that astronauts will eventually be able to receive surgical care while in space. The procedures could be carried out by telermentoring the astronauts aboard the spaceship.

Today, more than ever, surgeons must work to keep up with the newest surgical techniques and advancements. Efficient data management technology should provide effective tools to speed up the dissemination of innovative medical procedures. Clinical networks can play a key role in streamlining the use of medical technology by allowing data to be collected outlining physician practices, procedures, and patient outcomes which can then be used to identify the most effective procedure and related technologies. In this way, clinical pathways

can be established as the culmination of all the collected experience and knowledge. In aviation, for example, exactly defined procedures for the pilots to determine normal operation and emergencies is becoming a daily work routine.

The future has a lot in store. Tomorrow's medical environment and surgical equipment will undoubtedly be connected to communication networks, opening new horizons for surgical applications and knowledge exchange. As Tim Berners-Lee once stated: "The fact that we're all connected, the fact that we've got this information space, does change the parameters. It changes the way people live and work."

Image courtesy:

Fig. 1 and 2: Gary Armstrong, Barrow Neurological Institute, Phoenix, AZ, USA

See It All Come Together

An interview with Robert F. Spetzler, M.D.

The BNI is an internationally renowned neurological center where neurological procedures are the specialty. Since 1962 the Institute continues to unlock the mysteries of the brain and spine through pioneering research, cutting-edge technology, and intensive medical education. In the following interview, its director, Dr. Robert F. Spetzler, comments on collaboration and connectivity.

Barrow Neurological Institute (BNI) at St. Joseph's Hospital and Medical Center in Phoenix, AZ, is internationally recognized as a leader in neurological research and patient care. Since its beginning in 1962 when Charles Barrow made a generous gift to St. Joseph's Hospital to bring reality to Dr. John Green's dream of building a neuroscience institute, the BNI has grown to become one of the leading neurological specialty hospitals in the world. Along the way, it has established acclaimed subspecialty centers for stroke, brain tumors, epilepsy, skull base tumors, spinal disorders or pediatric neurology. The Institute is respected worldwide for its pioneering treatments, procedures and research into complex brain and spinal cord-related diseases and conditions. Professionals at Barrow generate more than 5,000 pages of academic material every year, including more than 200 journal articles and dozens of book chapters. Under the guiding influence of Dr. Robert F. Spetzler, who has been Director since 1986, the BNI has been brought into the 21st century. Dr. Spetzler is a world-renowned neurosurgeon who specializes in cerebrovascular disease and skull base tumors. He has been involved in pioneering the techniques of hypothermic circulatory arrest, a surgery now used

worldwide in treating complex aneurysms. He has contributed more than 300 articles and 180 book chapters to the neuroscience literature and has co-edited a number of neurosurgical textbooks.

INFORMED: Please describe some of the specialties of the Barrow Neurological Institute. What is unique about the BNI, and what are the most important accomplishments over the past four decades?

Spetzler: We are considered one of the world's foremost neurological centers because we perform so many unique as well as common neurological procedures every year. And to target difficult neurological conditions, we have created several specialized programs and centers. For example, we have established one of the few comprehensive hypothalamic hematoma treatment and research centers in the world – one of the few places where children can undergo surgery for these tumors.

We are dedicated to providing patients with cutting edge treatments and conducting groundbreaking research at our facility. Our clinicians develop innovative procedures to tackle some of the most



Robert F. Spetzler, M.D.

difficult diseases and conditions around. The resulting synergies have produced some of the most amazing innovations in the field.

Barrow surgeons and scientists helped pioneer the hypothermic circulatory arrest for the treatment of brain lesions. Currently, they are developing new endovascular techniques that thread tiny catheters into brain vessels to correct problems too risky for traditional neurosurgery. Our scientists recently identified a gene that causes the inherited form of cerebral cavernous malformations and have developed a blood test to identify people with this gene. They also have identified a specific neural pathway that carries the sensation of itch from peripheral nerve fibers up the spinal cord to the brain. This could explain how pain is transmitted and processed by the brain.

Moreover, the BNI is one of the few centers in the U.S. that offers the CyberKnife®, a noninvasive radiosurgery device for removing tumors. We were also one of the first neuroscience centers in the U.S. to offer Gamma Knife radiosurgery to treat brain

tumors and cerebrovascular malformations in critical locations of the brain, which represents a revolution in neurosurgery. And we are also one of the major clinical teaching and research centers for treating cerebrovascular disorders.

INFORMED: Networking and connectivity are popular topics today. Where do you see the greatest benefits for surgery by connecting the information flow of different devices?

Spetzler: Just take the CyberKnife® technology. It combines robotics and image guidance to deliver surgically precise radiation to destroy intracranial and extracranial lesions.

For me personally, image guidance which is integrated into the microscope, has made a huge difference because I operate on so many brain stem cavernous malformations. When you look at the brain stem, it can look perfectly normal and you don't know exactly where the lesion is located. Knowing that image guidance can help you



Barrow Neurological Institute (BNI) has become one of the leading neurological specialty hospitals in the world.

determine the exact trajectory that is best for a particular cavernous malformation has made a huge difference. That we can add on an endoscope and also see the image in the eyepieces – all that sort of integration and connectivity – has made a huge difference in how we perform neurosurgical procedures.

INFORMED:

In what way is OPMI Pentero important for you as far as connectivity and integration is concerned?

Spetzler: For the neurosurgeon, the microscope is the tool that allows us to do modern neurosurgery. So, the more functions that are integrated, the more effective we will be.

My favorite is indocyanine green videoangiography. The ability to look at blood vessels, to see the inflow and outflow, and to see whether an aneurysm is clipped appropriately has been an incredible boost. I recall three cases in which the aneurysm looked to be clipped perfectly through the microscope. Yet when we checked, there was no flow through one of the branches. Given how long it takes to do an intraoperative angiogram or the outcome of not doing an angiogram at all, those three patients most likely would have had a significant stroke. This new information is readily available and doesn't encumber the flow of the work. That makes a huge difference to us.

INFORMED: Does the exchange of intraoperative data and images play a big role for you

regarding the exchange with other clinical experts?

Spetzler: As a surgeon who spends a lot of time talking to other surgeons, being able to record operations and techniques is critical. The digital interface of OPMI Pentero can be integrated with the hospital system so that I can actually observe the digital images in my office. I have the ability to add to them online. Therefore, recording and distributing the information become very easy.

Live video, in particular, represents a valuable opportunity to interact with other surgeons during a

ing teaching institutions around the world, to allow fellows and residents to broaden their base of knowledge in the field. Besides generating academic material, our faculty members regularly conduct lectures at conferences about the latest surgical and medical innovations being developed at the BNI.

INFORMED: How do BNI surgeons share their knowledge and experience with the next generation of physicians?

Spetzler: We have created an academic structure that is based on our rich and diverse clinical experi-

“ We are dedicated to providing patients with cutting edge treatments and conducting groundbreaking research at our facility by paralleling and connecting neurological excellence.”

procedure, or to educate students sitting in the BNI's MedPresence Conference Room. The audience can gain knowledge and experience without being physically present in the OR. It provides a revolutionary advance in education and, by interacting with other surgeons, in surgical decision making.

INFORMED: Today, more than ever, surgeons must be willing to commit to keep up with the newest surgical techniques and advancements. How do you put this concept into practice at the BNI?

Spetzler: Both research and teaching are highly esteemed at the BNI and something of a tradition since its doors opened in 1962. Our mission is to improve patient care and to advance neuroscience knowledge by continually enhancing our capabilities in rehabilitation, imaging, and surgical techniques. Our staff participates in ongoing education in their respective fields. Grand rounds in neurosurgery, neurology, and pediatric neuroscience are held weekly, often hosting visiting professors from lead-

ence to provide current and future physicians with the education and experience needed to prepare them for a lifelong appreciation of medicine. The BNI has the largest neurosurgical residency program in the U.S. and thus is preparing the next generation of neurosurgeons and neurologists.

INFORMED: Thank you very much for this informative interview.

Image courtesy:

Barrow Neurological Institute, Phoenix, AZ, USA

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The Future of the Surgical Microscope in the Integrated OR

Jürgen Meixensberger, M.D., Ph.D.

IT networks play a key role in the modern hospital. The integrated OR requires state-of-the-art information and communication technologies as well as standardized interfaces. The surgical microscope is an ideal platform for streamlining various types of information – making it easily available for surgeons to access.



Fig. 1: Selecting pictures from OPMI Pentero within the OR.

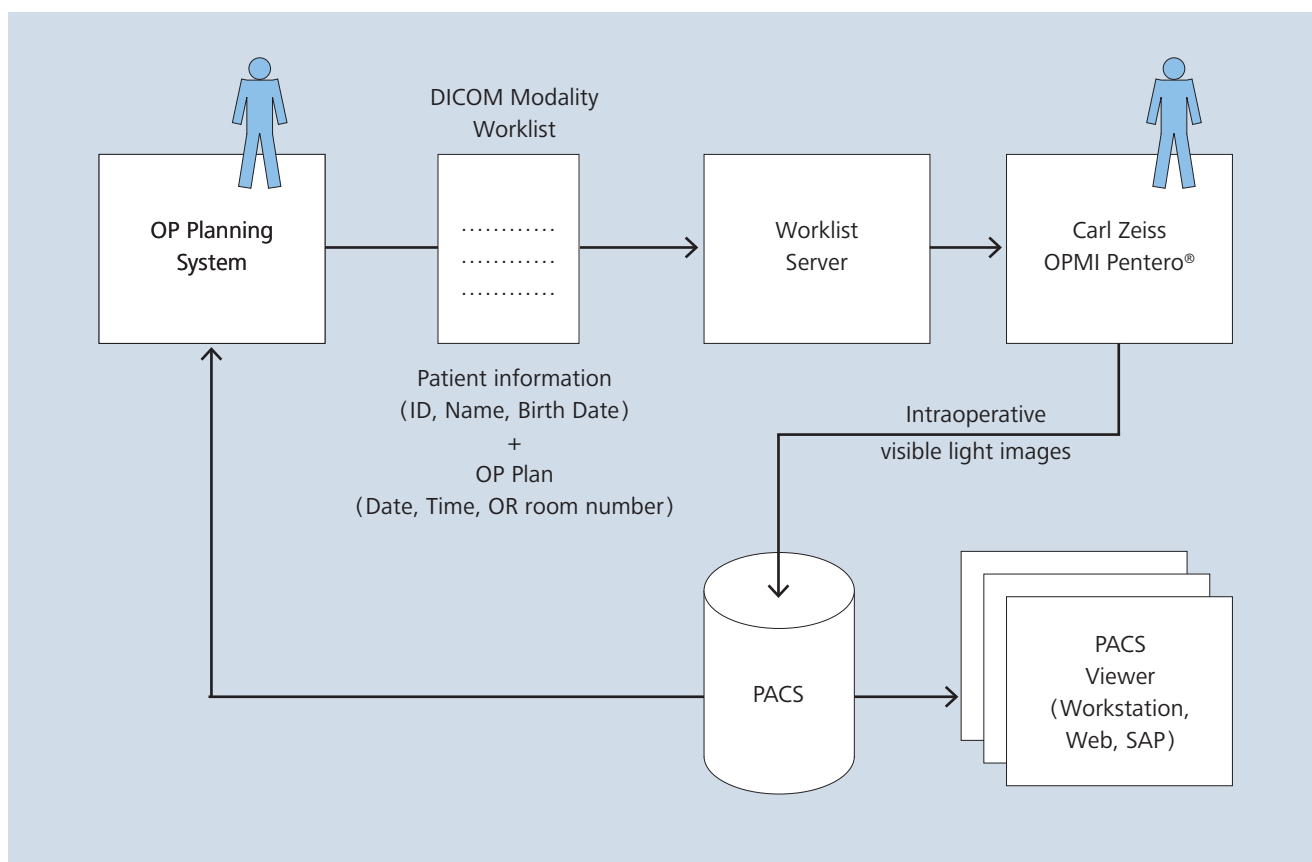


Fig. 2: Schematic data workflow and management for integrating OPMI Pentero for OR planning and documentation.

The need for swift and detailed digital information have led to the improvement and enhancement of modern imaging techniques. Thanks to the innovation of navigation technology, procedures such as magnetic resonance imaging (MRI) and positron emission tomography (PET) are used more frequently in surgical 3D treatment planning and execution. In addition to preoperative imaging, intraoperative real-time technologies and surgical documentation (e.g. used in the treatment of intracranial tumors and vessel deformities) are playing an increasingly important role influencing microsurgical strategy. Currently technical implementation is characterized by manufacturer-specific databases, the lack of a standardized viewer, and the lack of a uniform data format. However, intraoperative documentation of the surgical field and morphological/functional real-time data (with differentiated, indexed pre-operative imaging and

planning for image-supported treatment) is not sufficiently established due to a lack of standardization and networking in relation to integrated data management.

In the OR of the future

The operating room of the future will be marked by the increased use of assistant systems and minimally invasive procedures based on image and model patient data. However, achieving this advanced OR requires an integrated data management structure to allow for the capture of important relevant patient data. The connection to the hospital PACS can enable the surgical microscope to play a key role and provide the surgeon a surgical cockpit (integrated digital system). This can permanently support and improve surgery planning for the patients, as well as provide reliable documentation of intraoperative image information—such as addressing

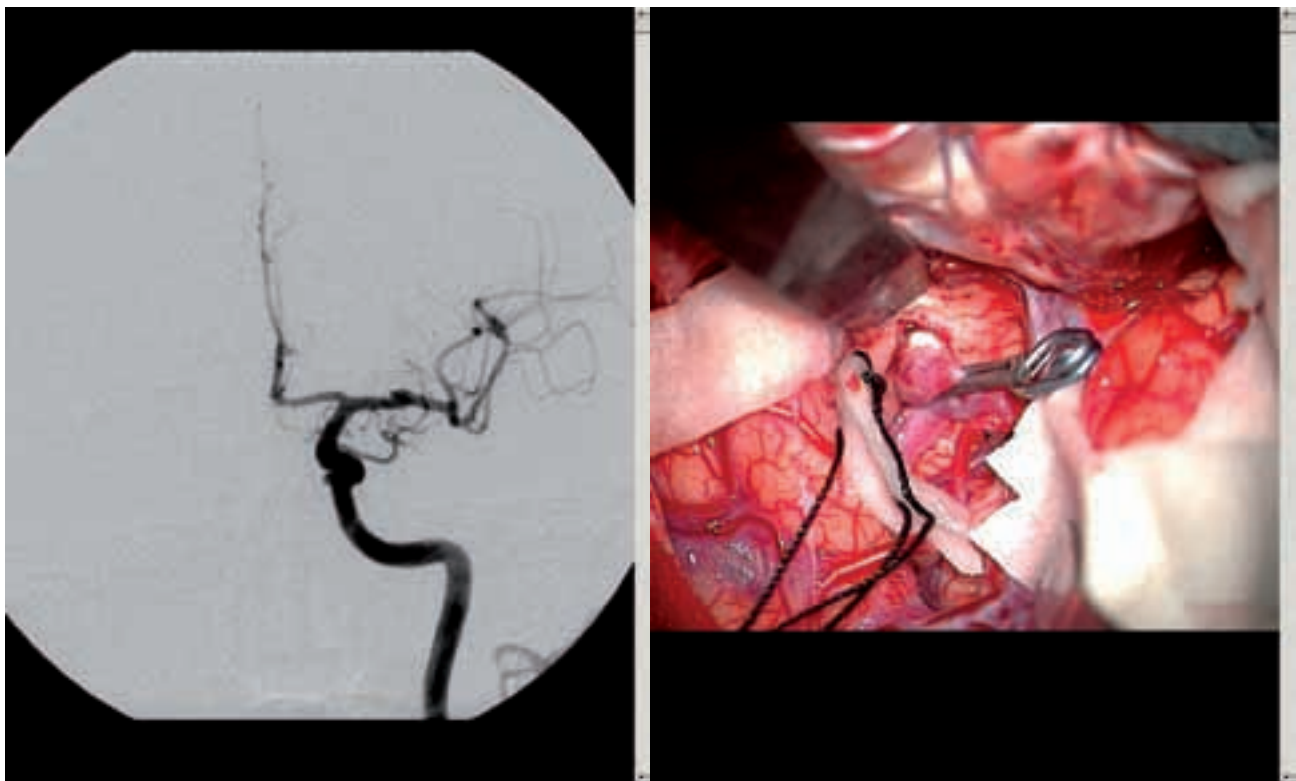


Fig. 3: Side by side view of a preoperative angiogram (left) and an intraoperative picture after clipping of a MCA aneurysm (right) within the archiving software.

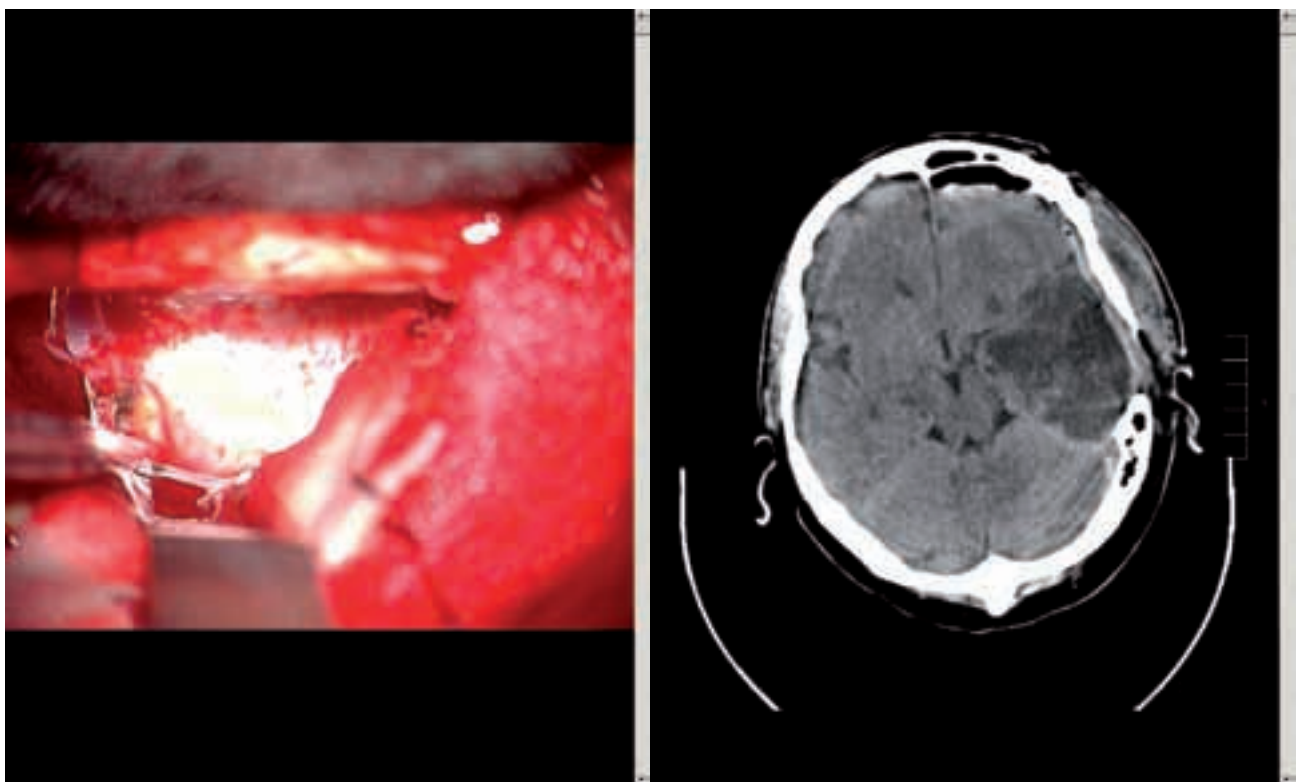


Fig. 4: Side by side view of an intraoperative picture at the end of a temporal tumor resection (left) and a postoperative control computer tomography (right) within the archiving software.

future clinical issues or responding to inquiries about outpatient aftercare and tumor follow-up.

Networking the surgical microscope

Carl Zeiss is advancing the technology driving systematic and standardized data flow for intraoperative management of imaging data. As part of a pilot project at the clinic and polyclinic of the University Hospital in Leipzig and the Innovation Center for Computer-assisted Surgery (ICCAS), the OPMI Pentero surgical microscope will be networked with the PACS hardware of the hospital via the DICOM module (Fig. 2). This project is intended to achieve the following objectives:

- Provide access to all patient image data in post-operative, outpatient aftercare
- Enable access to preoperative image data stored in the surgical microscope as an additional safety net (if the OR network fails)
- Forward data to referring office-based physicians via DICOM CD-ROM (including viewer)
- Establish and secure a consistent, standardized data flow by identifying patients with a uniform, hospital-specific ID

Patient image files can be noted on the surgical microscope before the procedure allowing the required image information to be selected by the surgeon from the PACS in radiology and loaded onto the surgical microscope. At the same time, a work list can be generated. The work list can be used to identify the appropriate patient during the operation, select specific preoperative images on the microscope monitor and record screenshots and videos. The surgeon can then verify and approve the data image quality, save the file post procedure, and store the data in the digital archive system. Utilizing an error analysis protocol, a plausibility check is mandatory as error sources can exist in the handling of the DICOM image series and in the allocation of the patient to the corresponding operation. The images can be postoperatively accessed with the viewer anywhere in the hospital via the PACS. Pre and postoperative data can be visualized

in different ways and compared in separate windows, for example (Figs. 3, 4).

Opportunities

The standardization and automation of intraoperative image data documentation permit high-quality documentation which can reduce the required personnel resources and possibly increase the clinical benefit. Initial experiences have shown that the surgical microscope is suitable for centralizing the function of image data availability and storage – allowing the data to be easily integrated into the radiology and hospital data management systems. The surgical microscope gives surgeons the opportunity to assume a central cockpit function in the digital operating room of the future. The standardized and reliable data management system running in the background has the potential to archive under one patient ID all intraoperative data such as C arm, ultrasound, CT, MR and make it useable for further clinical treatment and to process scientific-clinical questions.

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The Integrated OR: New Horizons in Improving the Surgical Workflow

An Interview with Paolo Cappabianca, M.D.

Located in the Medical Center of the University "Federico II" of Naples, Italy, the Department of Neurosurgery offers a full range of modern neurosurgical techniques, including skull-base, transsphenoidal, spinal, peripheral nerve and pediatric neurosurgery. Dr. Paolo Cappabianca, President and Chairman of the Neurosurgery Department, comments on the modern-day integrated operating room and his vision of the future.



Founded in 1973, the Neurosurgical Clinic of the University of Naples is a well-established reference center renowned for scientific contributions in the field of neurosurgery, especially in the neurovascular and spinal tumor field. The clinic became internationally recognized as a center of excellence where specialists in neuroradiology, neuropathology,

endocrinology, ophthalmology, otolaryngology, pediatrics, neurology, and anesthesiology work closely together, providing many specialized services. Recently, Prof. Cappabianca introduced – for the first time in Europe – transsphenoidal endoscopic surgery, a new approach to endoscopic surgery of certain brain tumors. In December 2007, he ex-



Paolo Cappabianca, M.D.

plained this new approach as a visiting professor at the Carl Zeiss Honorary Lecture, initiated and hosted by the Department of Neurosurgery of the Johann Wolfgang Goethe-University in Frankfurt/Germany. INFORMED met with Paolo Cappabianca,

tion systems, endoscopic carts and the improvements which came with the new generations of operation microscopes. These innovations have greatly increased the capabilities of neurosurgery. What makes a really fundamental difference between yesterday and today is the full integration of information technology in the modern OR and in medical technology in general. New hardware and software solutions provide completely new approaches – changing work in a modern OR by facilitating communication between every connection point, and by integrating the complete workflow in the OR which makes all required information available when and where it is needed. These new technologies promote opportunities to foster communication and learning.

INFORMED: Which major developments and trends do you foresee?

Cappabianca: The major developments for the modern OR will concern the integration of individual instruments and systems. Up-to-date surgical devices and instruments need to work together to be ergonomic as well as provide the surgeon control during

“ What makes a really fundamental difference between yesterday and today is the full integration of information technology in the modern OR and in medical technology in general.”

M.D., Ph.D., chairman and division leader in the Department of Neurosurgery at the University of Naples “Federico II”.

INFORMED: What are the main differences between the work in today’s OR as compared to the OR of 10 years ago?

Cappabianca: Today, we use surgical equipment and instruments in the neurosurgical OR which were not available 10 years ago – for example, naviga-

the operation. For example, the MultiVision technology of OPMI Pentero offers an intuitive open interface for virtually any additional visual information. To maximize the instruments’ capabilities and provide an improved OR workflow, it is best to connect them and allow the information to flow between all the instruments. In essence, the surgical microscope becomes part of the surgeon’s ‘cockpit’.

INFORMED: Which are the most important information interfaces required in the OR, and

what potential do you see in improving the workflow here?

Cappabianca: Among the most important information required in the OR is radiological image data. A major improvement is the interface to the radiological PACS which allows for direct access and displays the images in the OR. Furthermore, to be able to document, communicate and share the surgical procedures, the OR instruments need to interface with communication tools such as

PACS, images from Pathology (with the respective reports), operative videos and patient records. All these documents should be stored in a central database that is accessible through any secure connection.

INFORMED: What is your vision for the “OR of the future”?

Cappabianca: My vision of the OR of the future is a progressive miniaturization of various OR instruments – all controllable via computer or a remote

“ To maximize the instruments’ capabilities and provide an improved OR workflow, it is best to connect them and allow the information to flow between all the instruments.”

videoconference systems, dictation and telephone systems. It is possible to control what is happening during the operation either from the OR itself or from the surgeon’s office.

INFORMED: To what extent are you using video recording in your work, and what major benefits do you see?

Cappabianca: We record every operation for several reasons. The most important ones being to obtain material for scientific and didactic papers or videos, to review the cases and learn from possible errors, as well as to objectively demonstrate the results of the operation.

INFORMED: What improvements do you foresee would be advantageous in facilitating access and sharing of patient-related surgical data and information?

Cappabianca: I would like to have one central file for each patient containing all the possible multimedia information: Clinical records, images from

site – with big screens showing all patient information. Another advancement would be to make live surgeries available via teleconference systems which will allow sharing techniques, impressions and advice, with colleagues and experts in remote sites while performing the operations.

INFORMED: Thank you very much for this informative interview.

Image courtesy:

Paolo Cappabianca, M.D., Università degli Studi di Napoli Federico II, Napoli, Italy.

contact

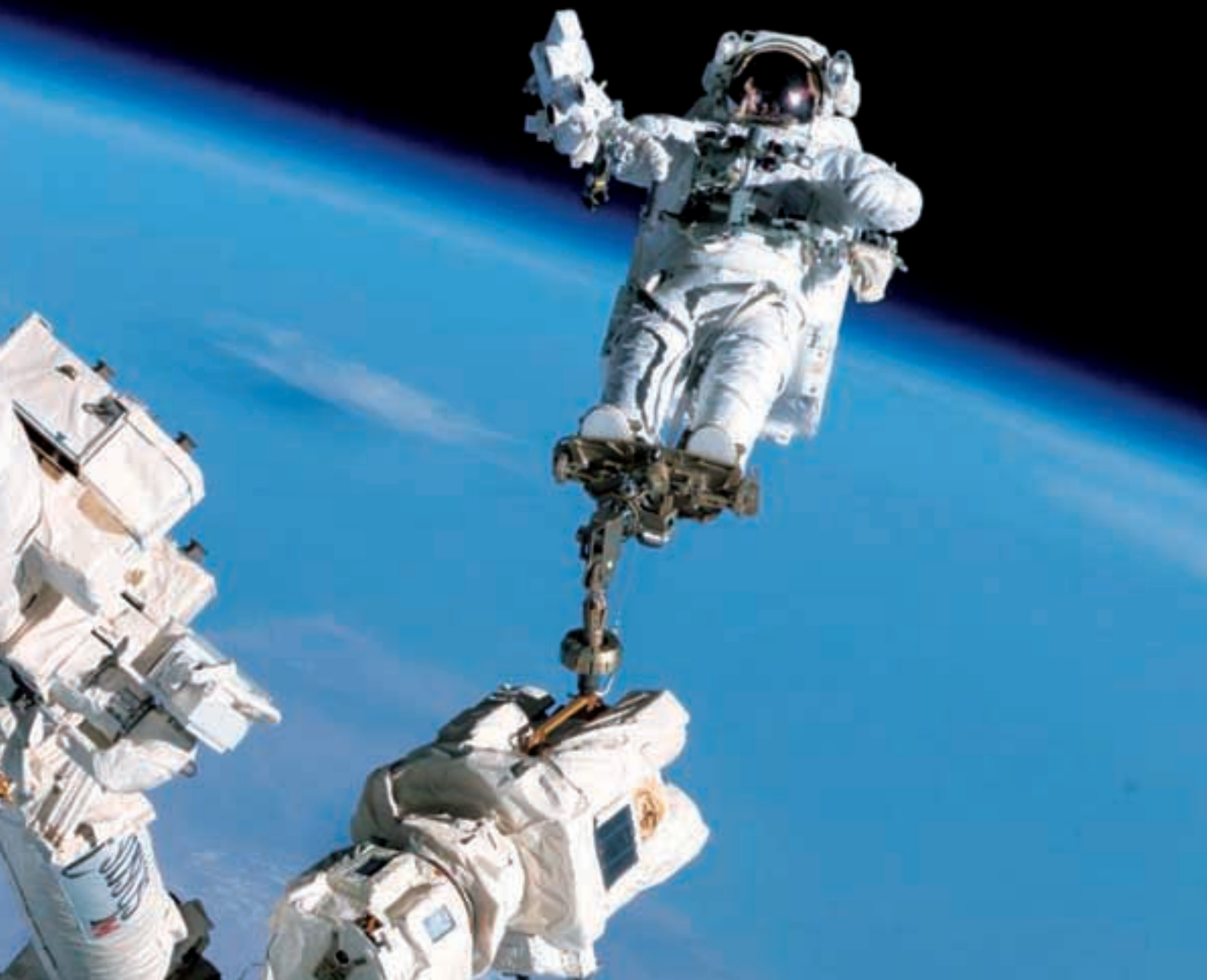
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Defying Gravity: Surgery in Space

Thomas Weber, Dr. rer. medic. Dipl.-Ing.

NASA's 50th anniversary offers a great opportunity to celebrate the power of inspiration, innovation and discovery. If scientists can put a man on the moon and consequently send him much farther into outer space, shouldn't it also be possible to enable astronauts to perform complex surgical procedures in zero gravity?



When an oxygen tank on board the Mir space station caught fire in February 1997, it was quickly doused – with the help of a fire extinguisher and a wet towel. Despite the risk of carbon monoxide poisoning and burns the crew was unharmed. However, emergency incidents such as this one re-

sulting in bruises, lacerations, burns or dental problems can always occur on a space station.

Naturally, there are guidelines in place to avoid leaving anything to chance. The individual responsible for handling procedures such as these is the Crew Interface Coordinator at the mission control

center on the ground. Particularly in critical medical situations, this person must be able to confer with someone onsite possessing the necessary training and experience. Thus, there is a Crew Medical Officer with basic medical training on board every flight who can discuss – and possibly perform – diagnostic findings and treatment planning together with the Crew Surgeon, the physician in charge at the control center. As such, a teleconsultation can be set up at any time. As with every doctor-patient relationship, confidentiality is also in effect between the doctor and the astronaut.

Deep Space

Every astronaut is subjected to thorough medical screening and status examinations. And naturally, there are more medical provisions on board than simply a first aid kit. Nevertheless, if the situation becomes too critical, there is always the possibility of returning to Earth. Plans and procedures for such an event do exist.

When flying to a far destination such Mars, however, an immediate return to Earth is no longer an option. In this case, careful consideration must be given to matters of prevention and care, and to how the necessary expertise of a given specialty can be imported to the space station or spaceship. Exporting the astronaut generally proves more difficult.

The military has pioneered the technology to enhance an immediate medical response. The challenges, for example, presented by exploratory missions to the moon and other planets are similar to those of a doctor on a naval ship, that cannot simply change course either. Naval physicians are general practitioners with additional medical training tailored for managing the unique medical situations which they may encounter.

On board a space station or a spaceship, a doctor accompanying a long mission should be a general practitioner, too, possessing additional knowledge in areas such as anesthesia, emergency medicine, cardiology and dentistry. Furthermore, this individual should have a basic education in psychology to serve as a confidant for colleagues in certain situa-

tions. Dermatology is yet another necessary field. It is essential that skin changes such as those caused by coming into contact with irritants are diagnosed. Telemedicine is a potential option, provided the images are true in color.

Yes, it's rocket science

Particularly to support surgical procedures, current technology trends are leaning toward the use of stereo, three dimensional images. Aerospace already possesses a broadband communications platform offering capabilities that far surpass audiovisual communication. Thus, virtual reality would be a possible next step to display data for doctors on board, and to simulate respective procedures for them with surgeons providing assistance from the Earth. To ensure the quality of treatment, it is crucial that these simulated images resemble reality as closely as possible, prompting the need for new forms of support measures to be developed. During a neurosurgical procedure, for example, a neurosurgeon on Earth can guide the colleague on board to assist in making decisions, provided they both can see the surgical field with clarity. Initial test results on new IT-guided procedures and sculpted 3D images have already been documented. Apart from the necessary visualizations and simulations, tactile perception must also be addressed. Surgeon sense varying pressure levels with the scalpel and other instruments, including tissue hardening, which is essential in medical procedures. The objective is to transmit the sensation and tactile feedback to an assisting surgeon who is not actually holding the scalpel to enhance the virtual reality experience for physicians not present, but assisting with the procedure. Moreover, signal delays and signal loss must be taken into account. What would happen should the communication channel be somehow interrupted? There are plans to localize expert knowledge, thus ensuring that it is always available for the individual on board. Yet, the audiovisual dialogue with a colleague cannot simply be replaced by a database. Thus, communication via light waves could prove instrumental for creating a fast and reliable link one day.

Today, it is almost certain that robots will not be used to operate on people in the future. All patients are different, have individual distinctions, and each surgeon works based on clinical experiences to make sound clinical decisions. Would a robot ever have the capability of making solid clinical decisions? Surely, there will be highly sophisticated mechanically support systems that provide assistance in maneuvering visualization systems – particularly for applications requiring a high level of precision; much like the use of surgical microscopes today. However, it is difficult to imagine an autonomously operating robotic surgeon. After all, procedures such as these must be clinically validated before being put into practice. What ethics commission would go along with this?

Creating a special OR area on board is hardly feasible either given the fact that launch weight largely determines costs. As a result, any idea that involves simply blowing up a shell cover to surround the surgical area will no doubt be given much more consideration. A proven idea already exists to simply encapsulate the surgical field itself, in other words, to drape the patient or respective bodily region of interest. The isolated area would then be properly prepared to be accessible with gloves, to allow adequate ventilation and the clean exchange of instruments – especially as sterilizing an entire space station is not an option.

Regarding diagnostics, having large imaging systems on board such as a MRI is also highly unlikely. Then again, portable low-field MRT systems, that is, closed or folding ring-shaped systems with magnetic field strengths of approx. 0.5 Tesla and an inner diameter sufficient for imaging human arms and legs, are by all means conceivable.

Back on planet Earth

Over the years, aerospace has continually pioneered efforts aimed at making medical technology smaller and mobile, as well as interactive. Already during Yuri Gagarin's space flight in 1961, ECG data were transmitted and telemetry employed. Further, the need for non-invasive, integrated sensors and diagnostics in aerospace led to the development of pul-

soximeters for non-invasive SpO2 measurement and pulse rate calculation, and also to the development of an automatic self tonometer to measure intraocular pressure without a second person providing assistance.

Considerations as to how medical knowledge, experience and skills can be combined and made readily available through communications will play an increasingly important role in the future, not only in space travel. There are also many applications for telemetry on Earth, particularly wherever fast availability of expertise is called for, as demonstrated by the medical emergency service of armed forces in operations conducted with a telemedical network. Natural disasters place equally special demands on aid workers, for whom not only the provision of emergency care for injured and disaster victims is a vital concern, but also more far-reaching issues such as the additional threat of epidemics. On-site teams gathering soil and air samples, for example, do not always have complete access to laboratory diagnostics and experience.

It will be essential for future developments in space medicine that medical companies and research centers closely coordinate their research and development efforts to design both innovative and practical products and technologies. Therefore, close cooperation between universities and respective institutes is an important step in the right direction – in the combined effort of shaping our future.

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Through the Lens of a Biomed Photographer: How to Take Good Pictures ?

Gary L. Armstrong

In our increasingly sophisticated world, maximizing technology for effective visual communication in medicine is more important than ever. That's where the job of a Biomed Photographer comes in and it all starts in the OR with digital video and photography.

As a photographer at St. Joseph's Hospital and Medical Center in Phoenix, Arizona, I encounter a wide variety of subjects to photograph and video record. From complex brain surgery to exotic craniofacial procedures to live intraoperative teleconferencing and even photo journal art, I get involved in a bit of everything. My job takes me right to the frontline of the multimedia explosion in medicine where I get to lay my hands on the latest emerging technology in visual communication. My main duty is to serve Dr. Robert Spetzler and his fellow neurosurgeons at Barrow Neurological Institute (BNI). As a member of the Multimedia Lab team, digital image capture in the BNI Operating Rooms is my area of responsibility. This year, out of Barrow's roughly 6,000 cases, we will video record 1,600 of them and shoot over 3,000 photographs. Those numbers testify to Barrow's investment in cutting-edge digital technology for documentation, lecture presentations, teleconferencing, interactive-multimedia, journal publication, research, and teaching. With eleven OPMI Pentero surgical microscopes and nine digital still cameras to setup and manage daily, I've done my share of intraoperative photography experimentation.

So, please consider the following tips and tricks:

External Digital Camera

For high-quality intraoperative still images, I use a digital Canon SLR camera for both microscope and hand-held photography. For high-resolution microscope photos, I externally mount the camera on OPMI Pentero co-observer port. The surgeon triggers the camera via the handgrips. A non-sterile observer can also trigger still picture capture from the scope's touch-screen. To mount a camera externally, you'll need three pieces of hardware: the ZEISS f = 340 photo adapter, the T2 adaptor ring and a camera cable. Once the camera is mounted, setup OPMI Pentero via its touch-screen by navigating through CONFIG, AUDIO/VIDEO, and PHOTO, then set the Mode Photo Button to "External". Next, navigate through STAND, HANDGRIP, LEFT and RIGHT, and assign "Photo" to the A and / or B buttons. Now you're setup to trigger the camera remotely via the scope handgrips and the PHOTO button on the scope's touch-screen main menu.

Controlling Image Exposure

Working without a camera lens and f-stops, you will have to manipulate the exposure in other ways.



Fig. 2: High-quality intraoperative still image of an aneurysm captured with an externally mounted camera on the microscope

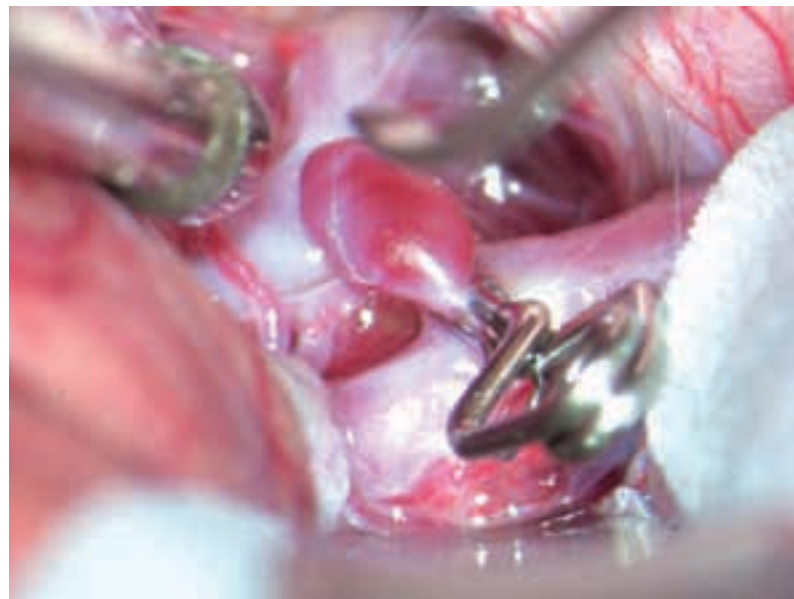


Fig. 3: High-quality microscope still image of a clipped aneurysm



Fig. 4: Maximizing technology for effective visual communication in medicine is more important than ever

Between the modes and settings of the camera and OPMI Pentero, you have several options. On the camera side, you can change three items: ISO, Shutter speed, and Auto Exposure Bracketing:

- ISO sets the light sensitivity of the camera's image sensor which typically runs from 100 to 1,600. Increasing the ISO increases the light sensitivity of the sensor, but also increases image "noise". Keep the ISO as low as you can.
- Shutter speed sets the length of exposure. Decreasing the shutter speed will increase your exposure, but also increases the chance of motion blur. Keep the shutter speed as high as possible.
- Auto Exposure Bracketing (AEB) decreases and then increases the normal exposure up to +2 stops in 1/3-stop increments over three successive shots. Think of it as exposure insurance for the often-unpredictable intraoperative situation. The downside is that the surgeon will have to pause while three pictures are taken. Note that this mode will

change the shutter speed to alter exposure.

The next set of exposure options reside on OPMI Pentero:

- Light Intensity can be varied from 0 to 100%. In my experience, this setting can change significantly from surgeon to surgeon and from procedure to procedure. If possible, use the same light intensity setting during intraoperative photography as your pre-surgery exposure setup.
- The "Flash During Capture" setting gives you a consistent level of light by flashing the light of OPMI Pentero regardless of its intensity setting. The downside is that the flash can be a distracting annoyance to some surgeons.
- "Depth of field" can be set to "Small" or "Large" and is found by navigating through CONFIG, OPMI, and DIAPHRAGM. The "Small" setting widens the scope's lens aperture, letting in more light and decreasing the depth of focus. The "Large" setting narrows the aperture, diminishing the light, but increasing the depth of focus. However, I use the "Small"



Fig. 5: Live video is revolutionizing the OR experience and establishing new possibilities in medical education and communication

setting because I have found that the shallow depth-of-field helps the surgeon to focus more critically.

As a place to start with these options, try a shutter speed of 125 at ISO 400 while setting OPMI Pentero to “Flash During Capture” and “Small” depth of field. I encourage you to experiment with these settings until an optimum exposure and focus is obtained.

Details, details...

It's often the overlooked things that spoil a photograph. Here are three items to keep in mind: Clean lenses, a clean sensor, and a blocked viewfinder.

- It's almost too obvious to mention, but I often find foggy residue on the scope lens having been cleaned with only a wet towel. I use ZEISS Lens Cloths religiously to keep both the scope lens and camera adapter tube lens clean. As the box declares, they are, “The ultimate convenience in lens cleaning

for the ultimate lens and coating technology.” Can't beat that.

- I'm often surprised how quickly dust accumulates on a camera's image sensor. You can waste a lot of time with photo editing software removing those pesky dark specks or you can keep the sensor clean. Consult your camera manual for cleaning instructions or visit your local camera repair shop.
- With the camera's viewfinder exposed, it is possible for stray light from the surgical field to affect your exposure. It's a good idea to block the viewfinder. I use a piece of black electrical tape.

Thinking photographically

Putting all the above technical issues aside, one big variable factor in getting terrific photographs is the surgeon behind the scope. So, be aware of the following:

- Focus, focus, focus! It simply must be spot-on for a great picture. Tip: Adjust the microscope's eyepieces. The eyes compensate for a subject slightly

out of focus. The subject may look sharp to the surgeon, but often the focus is quite soft for the camera. Turning on the "Focusing Aid Laser Spots" will help – they tell no lies.

- What you see is not what you get. Many beautiful shots are unacceptable because the main point of interest is off center and at the edge of the photo frame. The problem is that the surgeon's field of view is different than that of the camera. For accurate framing, a surgeon must imagine the aspect ratio of the camera's rectangular frame inside the circular view through the microscope's oculars. The bottom line: keep the main point of interest dead-center and frame your shot loosely. Use the "Focusing Aid Laser Spots" as a visual reminder of where center is.

Hopefully, with this basic knowledge, the right equipment and good technique, you'll soon be getting solid results with the microscope and camera which will enhance your visual communications. I want to encourage you to be creative, have some fun and start experimenting on your own. Then once you master the technical, you can forget about it because as legendary photographer Ansel Adams once said, "There are no rules for good photographs, there are only good photographs."

Good microscope photography takes persistence, but for me the real challenge starts when I get paged to the ORs for handheld photos. I never quite know what to expect, what the subject might be, how much time I'll have, or how many rooms I'll need to work simultaneously. Like the Boy Scouts, my motto has become, "Be Prepared." To my photographer's eye, the OR can be a perplexing tangle of light sources, awkward shooting angles, and extremes of contrast and reflection. Throw in the pressure of one-chance-to-get-it situations, time restraints, privacy requirements and sterile field limitations and that great picture can become rather elusive, but then, all the more satisfying when I nail that perfect shot.

In addition to still photography and recorded video, live video is revolutionizing the OR experience and expanding my area of service. An exciting breakthrough in intraoperative multimedia is the

BNI's MedPresence System. Establishing a new frontier in medical education and communication, MedPresence is a \$1.1 million video-conferencing system allowing students and other observers to interact live with surgeons in the OR. Seated in the MedPresence Conference Room, or in a similar room thousands of miles away, observers can speak with the surgeon while viewing the procedure from multiple perspectives. Well, in this new era of medical multimedia, it's hard to predict what the future might bring, but it's a good guess we will be viewing it in HD and 3D. Tomorrow's medical multimedia environment will undoubtedly be bigger, sharper, and more realistic. Watching a display will be like seeing through the eyes of the surgeon. One can only imagine what's next so be advised, start sharpening your multimedia skills now, as visually astute audiences expect more sophisticated presentations.

As a Biomed Photographer bobbing like a cork on this digital sea, I watch in wonder as the waves of change continue crashing over the medical landscape.

But that's a good thing – sweeping patient care, medical education, and life-saving knowledge from local shores to the world beyond.

Image courtesy:

Fig. 1: Steve Barbour, M.D., Phoenix, AZ, USA

Fig. 2 – 4: Gary Armstrong, Barrow Neurological Institute, Phoenix, AZ, USA

Fig. 5: Jackie Mercandetti, Phoenix, AZ, USA

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Expanding the Horizon of Clinical Education – Practical Anatomy & Surgical Education

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Developments in the medical field advance at a tremendous rate. The more sophisticated a technique, the more important training and education becomes. Hands-on workshops, in particular, represent an ideal opportunity to learn about newly developed technologies and applications. Individual workshops often spawn ideas, series or even whole training centers through close cooperation between physicians and industrial partners.



Surgeons have the ability to learn about newly developed technologies and applications in a most auspicious learning environment.

Medical progress leads to innovations that open up new opportunities in all medical specialties. So, now more than ever, surgeons must work to stay current with the newest surgical techniques and rapidly evolving medical advancements. From the very start of their training, medical students gain useful experience with the latest surgical methods during practical courses. These innovative surgical techniques often become a natural part of their professional lives as physicians dedicate themselves to the principle of lifelong learning.

The diversified programs of Practical Anatomy & Surgical Education (PASE) strive to promote the concept of lifelong learning by utilizing the latest technology to connect residents, health care professionals, and surgeons to world-class experts and faculty.

The PASE facility has a long-standing reputation that is widely regarded among the finest hands-on educational facilities for health care professionals anywhere.

Shaping the future of healthcare for over 20 years

Nearly 25 years ago, Paul H. Young, a clinical professor in Anatomy and Neurosurgery at Saint Louis University School of Medicine, founded a state-of-the-art healthcare education facility to provide hands-on workshops. Utilizing a new type of cadaver material, Dr. Young organized workshops on spinal and cranial techniques. The curriculum expanded to include presentations on peripheral nerve and spine, as well as brain anatomy and surgical procedures. The program has since expanded to in-



clude a growing number of new clinical disciplines and it has become a benchmark of practical clinical education in medicine. In 1988, the focus of the workshops was expanded to include hands-on training in the fields of orthopedic surgery, otolaryngology and plastic surgery. Three years later, in 1991, Practical Anatomy & Surgical Education organization found a permanent home in the St. Louis Metropolitan Medical Society building.

In September 1998, PASE became a division of the Center for Anatomical Science and Education at the Saint Louis University School of Medicine (which roots trace back to the founding of the American Association of Anatomists in 1888). Very recently, the building housing the PASE organization was renamed the PASE Learning Center (named after a

supporting charitable organization, Partners for the Advancement of Surgical Education).

The collaboration between PASE and Saint Louis University's Center for Anatomical Science and Education further enhanced the ability to continue providing unique educational programs in a broad range of surgical disciplines. Every year, approximately 1,500 physicians, nurses and allied health professionals attend PASE organized workshops. To date, health-care professionals from over eighty countries, representing all continents around the globe, have participated in hands-on training programs at the PASE Learning Center. The key to this success is the principle of bringing together a world-renowned faculty with cutting-edge technology, curriculum and surgical tools. Since its inception

PASE has remained dedicated to the development and presentation of innovative medical health and science workshops. The partnerships that have been forged with leading physicians, facilities and corporations provide an ongoing valued resource and support for the surgical community. In turn, the PASE program would have been impossible without the close support of these partners.

To the next level

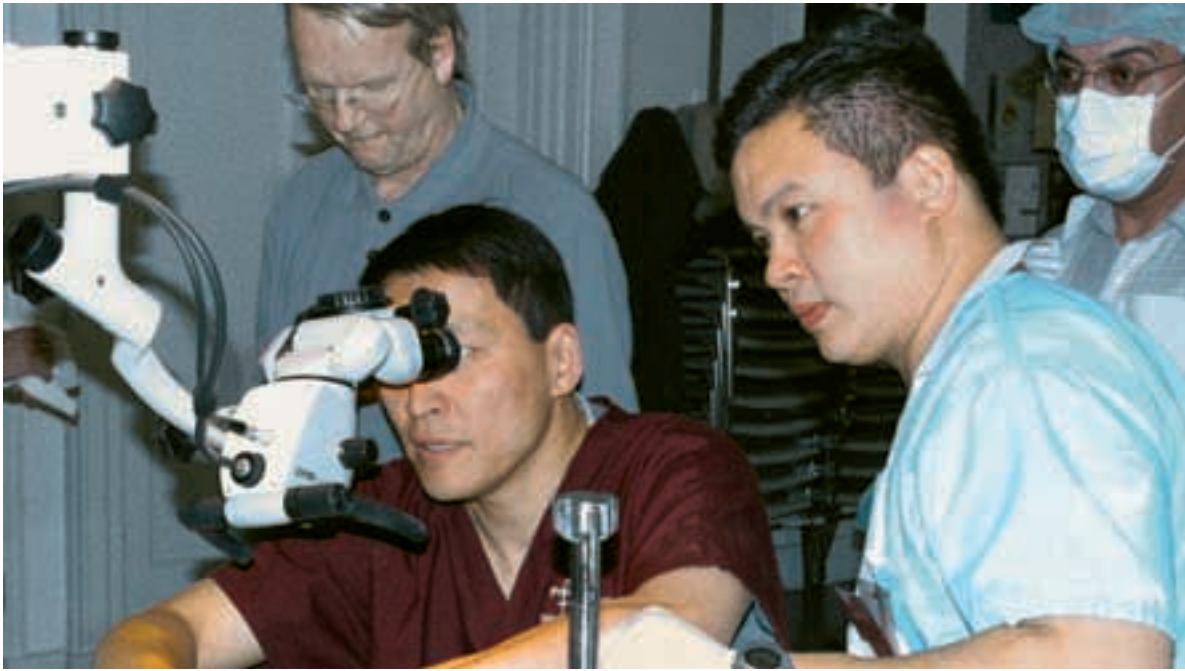
Because of the organization's design and commitment to education, PASE consistently attracts the world's leading surgical experts to instruct and lead workshops providing the highest standard of education for each specialty area. Medical students and residents are able to engage in a positive and constructive exchange with the foremost practitioners in each respective field. The dedicated commitment to practical education by medical device companies such as Carl Zeiss has ensured that the surgeons of tomorrow have the ability to learn the latest surgical techniques in a most auspicious learning environment. With the ongoing challenges of microsurgery, hands-on training with surgical microscopes and other instrumentation is a basic integral part of our program.

By providing innovative solutions for visualization during surgery, Carl Zeiss plays a major role in developing new forms of therapy, improving health and quality of life. When new technologies and fields of application are developed, these workshops benefit both physicians and Carl Zeiss alike, according to the motto "Give away everything you know, and more will come back to you", as author Paul Arden once wrote.

The support PASE has received from companies such as Carl Zeiss has kept us at the forefront as one of the world's leading education institutions. Carl Zeiss has been an instrumental industrial partner in helping PASE reach some of our major program milestones. In January 2003, "Lab A" officially was renamed the "ZEISS Learning Center" in honor of the donation of 26 new surgical microscopes. The Carl Zeiss sponsorship has elevated this state-of-the-art laboratory to the next level. The ZEISS Learning Center now consists of 26 dissection workstations equipped with floor mounted surgical microscopes, high-resolution monitors, suction, irrigation, and other essential surgical instrumentation which work to simulate a standard operating room setting. Step-by-step surgical procedures are demonstrated at the master workstation and are pro-



Hands-on training with the surgical microscope is an integral part of microsurgery courses.



Medical students gain useful experience with the latest surgical methods during practical courses.

vided through a direct video feed to each participant workstation.

Many influential medical organizations such as the American Academy of Orthopedic Surgeons (AAOS), American Association of Neurological Surgeons (AANS), Cervical Spine Research Society (CSRS) and the Congress of Neurological Surgeons (CNS) hold annual workshops in the ZEISS Learning Center at PASE.

Expanding the horizon

Since 1991, PASE has offered students and educators didactic and hands-on programs in medical and scientific related fields with its Adventures In Medicine and Science (AIMS). The AIMS programs introduce students to human anatomy and stimulate their awareness of good health practices. The hands-on programs provide an avenue of learning and discovery that help build important science literacy skills such as critical thinking, problem solving and teamwork.

In May 2002, AIMS began distance-learning presentations originating from the AIMS Virtual Anatomy Classroom. These unique programs provide hands-on interactive field trips designed to enhance any science curriculum. Utilizing the latest in

high-definition technology, distance learning offers similar opportunities for students worldwide through video conferencing. A remarkable mobile videoconferencing unit facilitates program broadcasts in high-definition from anywhere in the PASE Learning Center. Current plans include the expansion of the AIMS program to provide additional educational outreach in the spirit of what legendary statesman and author Benjamin Franklin once said: "An investment in knowledge always pays the best interest."

Image courtesy:

Practical Anatomy & Surgical Education, Saint Louis University School of Medicine, Saint Louis, MO, USA

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Getting Real with Your Virtual Cockpit

OPMI® Application Tip #4

Have you ever counted the number of monitors you need for data, images and videos during a complex surgical procedure?

The IT revolution in the OR has set higher standards, but it has also often led to isolated, individual solutions with extensive instrument technology requiring more and more monitors.

Modern surgical techniques have substantially increased the quantity of data and information diversity available to the surgeon. With the MultiVision™ function, Carl Zeiss has created a virtual cockpit for the surgical microscope which can be used to access required patient information at any time. The surgeon can see critical patient data in the eyepiece at the simple push of a button. This functionality turns the traditional surgical microscope into a control center, the hub of the OR.

"You have reached your destination"

Nowadays, GPS systems or digital maps are not the only devices that lead us to our destination when we are on the road. Due to the advent of high performance computers, intraoperative navigation is now an indispensable tool of many surgical procedures. In the field of neurosurgery in particular, the utilization of such systems has proven to be beneficial in many procedures. Additionally, the simultaneous use of an endoscope and a surgical microscope has been instrumental in order to effectively evaluate complex anatomical situations and to clearly visualize deep-lying structures not directly seen with the surgical microscope. However, how

can a surgeon process the constant flow of diagnostic, navigation and system information without having to take his eyes from the surgical field? Much like a pilot using an instrument display in his cockpit, the surgeon should also have all the essential information at his disposal on demand. For this purpose, the surgical microscope offers a unique platform for integrating essential patient data and pre-operative imaging information optimizing instrument positioning and navigation. The integrated MultiVision data injection system allows the surgeon to visualize navigation, image and video data easily and quickly in his microscope eyepiece and therefore, at the mere push of a button, obtain information for which he would otherwise have to search on different monitors in the OR. This combination permits the parallel use of modern technologies in an extremely efficient way. The following recommendations will help you obtain an optimum result for data injection in the MultiVision display.

Working with the data injection system

Depending on the image information desired, you can select between data injection excluding the object visualized through the microscope (image



MultiVision allows the surgeon to easily and quickly display navigation, image and video data in his microscope eyepiece.

injection) or the transparent visualization of the image information which is overlaid on the object display through the microscope (superimposing). After mode switchover, the current operating mode is displayed as text information for a few seconds in the eyepieces. Please remember the following tips when working with MultiVision:

- Have the point of interest in autofocus injected into the image center in the form of crosshairs in the eyepiece. This is of particular benefit in mouth switch control ensuring perfect video image definition. If a navigation system is connected, system-specific crosshairs should be injected.
- If in OPMI® Pentero® you inject the complete graphic touchscreen interface into the eyepieces, you can change settings and system configurations with the joystick of the right handgrip without compromising sterility.
- Prior to the procedure, set the configuration menu for the INFRARED 800 application in OPMI Pentero so that the content of the touchscreen monitor is also projected into the eyepieces. This way, you can be guided through the procedure without having to take your eyes from the surgical field.

MultiVision configuration menu of OPMI Pentero

In the configuration menu of the MultiVision function for OPMI Pentero there are various settings for data injection which can be performed in the display.

- Save your personal settings for key assignment for the MultiVision function on the handgrip or footswitch, for the brightness and contrast of the display. These functions will then be available again at any time with the same user profile for the next procedure.
- Prior to the procedure, choose the type of display for the MultiVision key function: Navigation, endoscope camera or touchscreen display. With simultaneous operation of the navigation system and the endoscope, the injection of the endoscope image has precedence when the MultiVision key is pressed. Transparent navigation data is then deactivated.
- In the configuration menu you can also define what system information, either individually or together, is to be constantly projected into the MultiVision display: current zoom value, current focus position, current light intensity.

IGS data of the navigation system

In the OPMI Neuro MultiVision/NC4 system, the contours for the navigation procedure are superimposed on the current surgical image in the form of a monochrome display. In the OPMI Pentero the binocular MultiVision system also permits the display of colored contours in the superimposing mode.

- With the navigation interface activated, the information is automatically projected from the navigation system into the MultiVision display. If you now press the MultiVision button programmed for navigation, the shutter is closed and only the injected navigation image is displayed. Another press of the button opens the shutter again and superimposes the navigation data and the microscope image.
- This option allows you to also directly control functions of the connected navigation system using the joystick of the right handgrip (system-dependent).
- Also, with a connected navigation system and activated navigation interface, you can program the MultiVision button with a different function for the endoscope camera or touchscreen display.
- For navigated surgery, it is recommended to use the autofocus as doing so guarantees that the targeted point on the surface corresponds to the point on the screen of the navigation system. This allows you to avoid errors caused by the large depth of field or misaligned eyepieces.
- Connect the supplied synchronization cable to the OPMI Neuro MultiVision/NC4 System. This connection synchronizes the MultiVision display with the video camera of the microscope. If it is not connected, flickering and even the partial disappearance of injected data and contours may result on an externally connected monitor.
- In the INFRARED 800 application, the infrared cameras of navigation systems may cause disturbance in the INFRARED 800 video image on the screen display. Prior to the procedure, perform a function test using the fluorescence target for INFRARED 800 in order to check whether any reflections

are being caused by the positioning of the infrared light sources and reposition them if necessary. If any reflections occur, prevent or minimize the presence of light by tilting or covering the eyepieces.

- Ensure that if an antenna has been installed for the navigation system the permissible overall weight on the surgical microscope including accessories (e.g. spine adapter, camera adapter, stereo observation tube, micromanipulator) does not exceed the limits specified in the user manual.

Video signals

External video sources such as an endoscope camera can be attached to the surgical microscope via the "Video In" Y/C video data interface on the suspension system. This connection can be completed in a "plug and play" manner without any further accessories as the MultiVision system automatically recognizes NTSC and PAL video signals.

- Use the connecting cable supplied with the microscope to connect a video source to the surgical microscope.
- The shutter which removes the surgical image is only activated when appropriate such as when an external video signal is also available. When selecting an input without a valid signal, you will see a corresponding message for a few seconds in the display.
- If in the OPMI Neuro MultiVision/NC4 System you chose not to view the simultaneous endoscope image in the right eyepiece and the surgical image in the left eyepiece, set the shutter so that the left eyepiece remains closed, i.e. black, when the endoscope image is injected into the right eyepiece. In OPMI Pentero, the endoscope image is always injected into both eyepieces.

Outlook

The further development of micro-display technology will also improve the performance of data injection systems. In the future, additional data and new networking concepts will be used for systems not only in the OR, but in the entire hospital and between different hospitals in order to provide the surgeon with all the information required for the procedure – in his virtual cockpit simply and quickly.

Microscope-integrated, Intra-operative, Near-infrared ICG Videoangiography in the Case of Cerebral Arteriovenous Malformations

Yasushi Takagi, M.D., Ph.D.; Nobuo Hashimoto, M.D., Ph.D.

ICG videoangiography is a safe and simple method with which to assess the microcirculation of the brain. In this report, we show two representative cases which demonstrate the efficacy of ICG videoangiography in the field of cerebrovascular surgery.

Fluorescence angiography was first used by ophthalmologists to measure retinal blood flow by using the fluorescent dye fluorescein.¹⁰ Feindel et al. were the first to apply the concept of fluorescence angiography to the intraoperative visualization of cerebral vertebral arteries and cerebral microcirculation in patients undergoing neurosurgical procedures.^{1,2,4} With the use of indocyanine green (ICG) as a novel fluorescent dye, and its integration into a compact system that takes advantage of modern video technology, fluorescence angiography has recently re-emerged as a viable option.^{8,9}

Methods and patients

Carl Zeiss has integrated ICG videoangiography technology into its OPMI Pentero surgical microscope. The system was designed to obtain high-

resolution and high-contrast near-infrared (NIR) images. For the presented cases, the operative field was illuminated by a light source with a wavelength covering part of the ICG absorption band (range 700-850 nm, maximum 805 nm). Indocyanine green dye was injected into a peripheral vein as a bolus (the standard 25 mg dose dissolved in 10 ml of water). ICG fluorescence was induced after the dye solution arrived in the vessels of the NIR light-illuminated field of interest. The fluorescence (range 780-950 nm, maximum 835 nm) was recorded by a non-intensified video camera. An optical filter blocked both ambient and excitation light so that only ICG-induced fluorescence was collected. Thus, arterial, capillary, and venous angiographic images could be observed on the video screen in real time. The setup allowed high-resolution NIR images based



Fig. 1: Intraoperative visualization methods supplement the optics of the surgical microscope and open up new dimensions in vision.

on ICG fluorescence to be visualized without eliminating visible light during the investigation.

From January 2007 to March 2008 a total of 32 patients received ICG videoangiography during a surgical procedure at Kyoto University Hospital. Among them, 8 cases of extracranial-intracranial (EC-IC) bypass, 4 cases of cerebral arteriovenous malformations (AVMs) and 13 cases of cerebral aneurysms were included.

Illustrated cases

Case 1: A two year-old girl presented sudden-onset hemiparesis due to intracerebral hemorrhage. Cerebral angiogram disclosed a Spetzler and Martin grade III AVM in the left frontoparietal lobe. Preoperatively, the feeders from anterior cerebral arteries were embolized by endovascular surgery. She received a frontoparietal craniotomy and the nidus was removed. Intraoperative cerebral angiography

could not detect residual nidus. Nine days after the operation, a cerebral angiogram indicated residual nidus fed by the anterior cerebral artery, with early venous drainage. During these procedures, the right femoral artery was occluded. Thus, we decided not to use intraoperative digital subtraction angiography. She received an additional operation using ICG videoangiography and neuronavigation. ICG videoangiography indicated a nidus with early venous drainage in this area. After temporary clipping of the feeder, the residual nidus was completely removed. ICG videoangiography also indicated total removal of the nidus (Fig. 2 a-f).

Case 2: A 10 year-old girl showed intracerebral hemorrhage. Cerebral angiography revealed a Spetzler and Martin grade I parietal arteriovenous malformation. We planned to perform parietal craniotomy for removal of the AVM. After the nidus was totally dissected from surrounding brain paren-

chyma except for the draining vein, ICG videoangiography demonstrated that the nidus was not visualized without draining vein but only with to-and-fro flow of ICG.

Discussion

The integration of the ICG videoangiography technique into the surgical microscope improved the simplicity and speed with which the procedure can be used. There is no need to move the microscope from the surgical field or to interrupt the operation.⁹ The results of ICG videoangiography were available within several minutes for all patients. Moreover, this imaging technique can easily be repeated as needed. Consequently, ICG angiography may be an easy-to-use tool for intraoperative quality control and documentation of surgical outcomes.^{8,9,11}

The two cases of cerebral AVM demonstrate that ICG videoangiography was useful in the treatment. ICG videoangiography is effective in the cases in which cerebral AVMs are located in the superficial surface of brain. In the first case, we can confirm complete dissection of the nidus without antegrade flow in the drainer. As for AVM removal, several novel technologies were applied. Neuronavigation was one of them and useful in safe removal.^{5,6} But it cannot assess the flow of AVMs. Residual nidus of AVMs was easily re-ruptured according to previous reports.³ In that case, the right femoral artery occluded during the first operation. Thus, we could not employ intraoperative cerebral angiography.

In the field of cerebrovascular surgery, ICG videoangiography demonstrated the possibility of improving operative outcomes. As for EC-IC bypass, ICG videoangiography can reduce early bypass graft failure and improve surgical results in EC-IC bypass surgery.¹¹ Based on this, a reliable intraoperative assessment of EC-IC bypass function would be beneficial and may help decrease surgical risks.

Wortzik et al. reported that ICG videoangiography was useful for revision of 4 of 35 STA-MCA bypasses.¹¹ In addition, all 4 cases exhibited good filling of the bypass according to repeated ICG videoangiography. In our cases, it could detect early bypass failure in 1 of 8 cases.

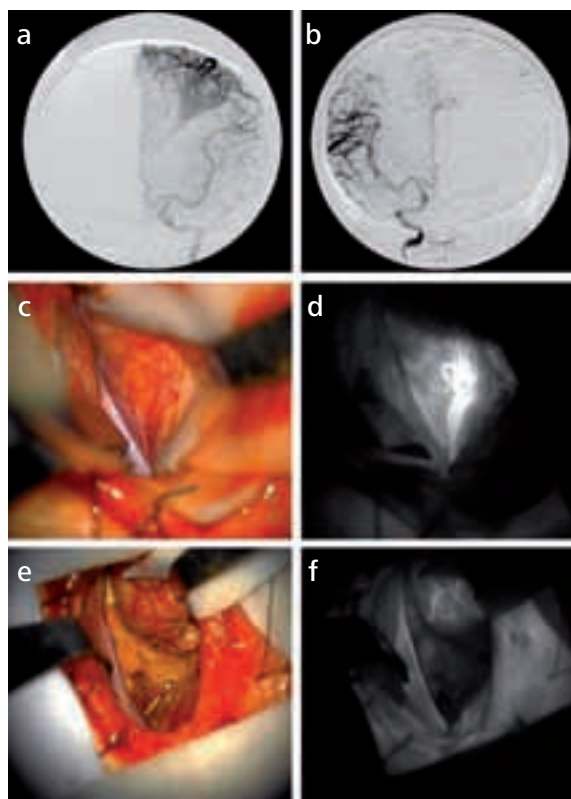


Fig. 2: The use of ICG videoangiography in the case of cerebral arteriovenous malformations (AVMs). Preoperative cerebral angiogram: anterior-posterior view (a). A diffuse-type Spetzler–Martin grade III arteriovenous malformation can be seen in the left frontoparietal lobe. Cerebral angiogram obtained after first operation: anterior-posterior view (b). The residual nidus fed by the anterior cerebral artery can be seen. Surgical view (c and e) and indocyanine green angiography (d and f) during the second operation: The residual nidus fed by the anterior cerebral artery (c) was removed (e). ICG disclosed that the residual nidus (d) was totally resected (f).

Raabe et al. also showed that the findings identified on ICG videoangiography were consistent with those on postoperative digital subtraction angiograms.^{8,9} As for cerebral aneurysms, the ICG technique provided information relevant to the surgical procedure in 9% of cases, including vessel occlusion or stenosis and residual filling of aneurysms.^{8,9} Among our 14 cases of cerebral aneurysms, we rearranged the position of clips in 2 cases based on the image of ICG videoangiography. Perforating ar-

teries are commonly involved during the surgical dissection and clipping of intracranial aneurysms. During aneurysm surgery, Oliveira et al. reported that perforating arteries were found in the surgical field in 36 of 64 cases.⁷

In addition to the above-mentioned cases, ICG videoangiography has the potential to detect shunt point in dural arteriovenous fistula and the patency of dural sinus during tumor surgery. During carotid endoarterectomy, ICG videoangiography can detect the location of plaques and show the patency. We already have several methods of assessing cerebral circulation during surgical procedures. In the further study, it is necessary to confirm the difference of the results among intraoperative cerebral angiography, Doppler ultrasonography and ICG videoangiography.

In summary, we were able to show the efficacy of ICG videoangiography in cerebrovascular surgery in this report. ICG videoangiography has the potential to achieve the goal of routine intraoperative vascular imaging during cerebrovascular surgery.

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Image courtesy:

Fig. 1: Yasushi Takagi, M.D., Ph.D., Department of Neurosurgery, Kyoto University Graduate School of Medicine, Japan

Fig. 2: Journal of Neurosurgery: Pediatrics, published by the American Association of Neurological Surgeons, Charlottesville, VA, USA

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Facts and Figures

Invention of the optical telegraph: **1794**

First successful electric telegraph message sent by Samuel Morse: **1844**

First successful telephone transmission made by Alexander Graham Bell: **1876**

Sputnik launch as the first artificial space satellite: **1957**

Demonstration of a telemedicine link of over 112 miles from the University of Nebraska Norfolk State hospital: **1964**

Creation of ARPAnet as the world's first computer network: **1969**

First robot-assisted surgery in placing a needle for a brain biopsy: **1985**

Tim Berners-Lee invented the World Wide Web: **1989**

Carl Zeiss develops the MKM, the first surgical microscope for navigation linked to a computer: **1993**

Carl Zeiss introduces MultiVision display concept: **2000**

First robotic surgery in the removal of a brain tumor: **2008**

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Estimated length of undersea cables linking all parts in the world: **107,000 miles**

Estimated number of world-wide Internet users by 2008: **1.4 billion**

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